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MULTIVARIATE ANALYSIS OF SOME PINE FORESTED AREAS OF AZAD KASHMIR-PAKISTAN

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Abstracts

Floristic composition and communities in Azad Kashmir area of Pakistan were studied by using multivariate analysis. Quantitative sampling from thirty one sites was carried out in different coniferous forests of Azad Kashmir in order to analyze the effects of past earthquakes and landslides on vegetation of these areas. Though coniferous forests were highly disturbed either naturally or anthropogenic activities, therefore sampling was preferred to those forests which were near fault line. Trees were sampled using Point Centered Quarter (PCQ) method. Results of cluster analysis (using Ward's method) yielded six groups dominated by different conifer species. Group I and V were dominated by *Pinus wallichiana* while this species was co-dominant in group III. Other groups showed the dominance of different conifer species i.e. *Cedrus deodara*, *Pinus roxburghii*, *Picea smithiana* and *Abies pindrow*. Both the cluster analysis and ordination techniques (by two dimensional non-metric multidimensional scaling) classify and ordinate the structure of various groups indicating interrelationship among different species. The groups of trees were readily be superimposed on NMS ordination axes; they were well classified and well separated out in ordination. The present research revealed that these forests had diverse and asymmetric structure due to natural anthropogenic disturbances and overgrazing, which were key factors in addition to natural disturbances. However, some of the forests showed considerably stable structure due to less human interference.

Key words: Multivariate analysis, NMS ordination, Ward's cluster analysis, Pine forests, Azad Kashmir, Pakistan

Introduction

Azad Kashmir, Pakistan known as Heaven on earth whose mountains are mostly covered with different species of conifers along with wide range of broad leaved species. The forests are floristically rich and they are diverse in their composition. Due to natural catastrophe and anthropogenic interferences, forests are disappearing gradually.

Northern areas of Pakistan including Azad Kashmir are frequently affected by earthquake and landslides. The large-scale earthquakes have been reported from various parts of Northern areas of Pakistan (Bokhari *et al.,* 2013). The State of Azad Jammu and Kashmir is located in the Northeast of Pakistan. It is a mountainous area, with India, China and Afghanistan as their neighboring countries. Azad Kashmir (24-37^{o}N, 61-78^{o}E, 796,099 km^2, south Asia) is a land of geographic diversity, southern and eastern parts occupied by plain terrain, while mountains of varying heights are present in western and northern parts. It consists of an arc-shaped stretch of territory with an area of approximately 13,296 sq km bordering Indian-occupied Jammu and Kashmir to the East, Punjab to the South and Khyber Pakhtunkhwa province (previously NWFP) to the West, and the Northern Areas (NA) of Pakistan to the North. Azad Kashmir has very significant geographical distribution among mountainous ranges. It comprises foothills of the Himalayas rising to Jamgarh Peak (4, 734 m) with the North-western reaches of the Pir Panjal Range (3,753 m) to the South. Azad Kashmir can be divided into two geographical zones, hilly and mountainous to the North and East while areas to the South and West consist mainly of valleys and plains. Temperature and rainfall vary across the four districts of Azad Kashmir and adjacent Northern Areas (Singh *et al.,* 2004, Afshan *et al.,* 2011).

Raja *et al*. (2014) did multivariate analysis of vegetation in moist temperate forests of Pakistan. They discussed floristic composition and hierarchical diversity in these wet temperate forests. Siddiqui *et al.* (2010) investigated vegetation-environmental complex of pine forests of moist temperate area of Pakistan using advanced multivariate techniques. In the present study moist temperate forests of Azad Kashmir are studied with the help of sophisticated multivariate techniques from broad ecological and disturbance perspectives. The study area consist of sub tropical pine to moist temperate forests of Azad Jammu and Kashmir, which are located near fault line and the forests are disturbed either naturally or due to anthropogenic activities. Sudhan Gali, Chakothi, Chakar, Kail, Pir Chinasi, Keran, Muzaffarabad and Sharda were the main sampling sites in present study. Bokhari *et al.* (2013) conducted phytosociological studies in these areas but since that no advanced multivariate analyses were carried out in this area (Fig. 1). Characteristics of sampling sites are shown in Table 1.

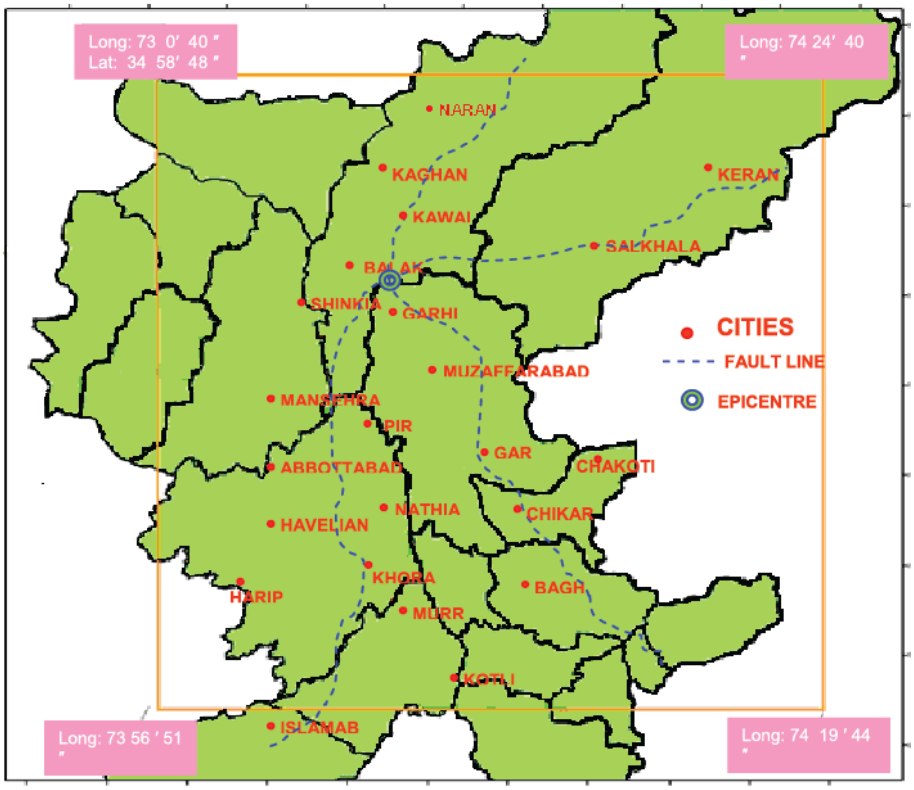

Fig. 1 Map of Study area, showing main earthquake sites/fault lines in Azad Jammu & Kashmir, Pakistan

Materials and Methods

Quantitative sampling from thirty one stands were carried out in different coniferous forests of Azad Kashmir, Trees were sampled using Point Centered Quarter (PCQ) method described by Cottam & Curtis (1956). According to Greig-Smith (1983), this method gives reliable overall density and relative density estimates.

Phytosociological attributes (relative frequency, density and basal area) and absolute values (stand density ha^{-1} and basal area m^2 ha^{-1}), were calculated according to the methods described by Mueller-Dombois & Ellenberg (1974); Ahmed & Shaukat (2012). Following the method of Brown & Curtis (1952), importance value was used to rank each species in stand and the species was considered dominant on the basis of their highest importance value. Plants specimen were collected from the study area. Identification and Nomenclature of plants usually followed Flora of Pakistan (Ali & Qaiser, 1995-2015; Nasir & Ali, 1972-1994, Stewart, 1972). At all sampling stands, important site characteristics were also observed.

Primary ecological features (Latitude, longitude, elevation and aspect) of all sampling sites were recorded by using a handset of Global Positioning System (GPS).

Numerical data from thirty one different forests of Azad Jammu and Kashmir was subjected to multivariate analysis. Both cluster analysis and ordination techniques were used to classify structure of various group and interrelationship among different species. The statistical program (PC-ORD Version 5.10) was used. Among various clustering techniques, Ward's Hierarchical agglomerative clustering techniques (McCune & Grace, 2002; McCune & Mefford, 2005) were employed to classify various sampled forest stands. For cluster analysis, importance value of trees was used as it gives dominance and distribution of a specific species in a community of that specific area (Kent & Coker, 1992; Song *et al.,* 2009). In this process of classification of vegetation groups, those species which were less than 3% of the forest stands were not included in order to avoid undue affect of rare species. This approach was also adopted by Shaukat (1989); McCune *et al.* (2000); Siddiqui *et al.* (2010); Ahmed *et al.* (2011); Bokhari *et al.* (2013) and Raja *et al.* (2014).

To analyze the interrelationship among all the other ordination techniques, non-metric multidimensional scaling (NMS) based on Bray-Curtis similarity index was preferred between plant communities. This is due to the reason that it does not depend on the assumption of multivariate normality. Secondly, in this scaling, the vegetation samples are arranged in a specific dimensional space according to their order of ecological similarity (McCune & Grace, 2002; Enright *et al.,* 2005). According to Minchin (1987) NMS system provides ordinations which are improved and ecologically defined. Moreover, it gives robustness to maximum zero values and resistance to quantitative noise.

Table 1. Characteristic features of sampling sites of Azad Jammu and Kashmir.

Sr. No.	Main locations	Sites name	Latitude (N)	Longitude (E)	Elevation (m)	Aspect
1.	A- Chakothi	Mora Sadiq	34° 11′	73° 88′	2114	NE
2.		Mora Sadiq	34° 05′	73° 26′	2100	SW
3.		Mora Sadiq	34° 05′	73° 51′	2070	S
4.		Mora Sadiq	34° 05′	73° 51′	2070	NE
5.		Chakothi	34° 08′	73° 51′	1111	W
6.	B- Keran	Keran	34° 39′	73° 56′	2040	W
7.		Keran	34° 16′	73° 88′	2018	W
8.		Keran	34° 22′	73° 79′	1997	NE
9.	C- Kail	Arrung Kail	34° 49′	74° 21′	2743	SW
10.		Arrung Kail	34° 48′	73° 20′	2743	SW
11.		Arrung Kail	34° 48′	73° 21′	2743	E
12.		Kail	34° 48′	73° 21′	2663	W
13.		Kail	34° 48′	73° 21′	2600	SW
14.		Kail	34° 47′	73° 51′	2550	NE
15.		Kail	34° 47′	73° 51′	2505	NE
16.		Kail	34° 47′	73° 51′	2445	WN
17.	D- Sharda	Sharda	34° 46′	74° 09′	2134	N
18.		Sharda	34° 46′	74° 09′	2134	N
19.		Sharda	34° 46′	74° 09′	2134	NE
20.		Sharda	34° 43′	74° 08′	1852	N
21.	E- Muzaffarabad	Muzaffarabad	34° 23′	73° 27′	799	NE
22.		Muzaffarabad	34° 22′	73° 28′	833	NE
23.	F- Pir Chinasi	Pir Chinasi	34° 22′	73° 32′	2900	N
24.	G- Sudhan Gali	Sudhan Gali	34° 24′	73° 44′	2510	SW
25.		Sudhan Gali	34° 22′	73° 28′	2500	N
26.		Sudhan Gali	34° 20′	73° 22′	2450	E
27.		Sudhan Gali	34° 19′	73° 25′	2420	W
28.		Sudhan Gali	34° 19′	73° 25′	2400	N
29.		Sudhan Gali	34° 19′	73° 25′	2390	N
30.		Sudhan Gali	34° 19′	73° 25′	2390	NW
31.	H- Chikar	Chikar	34° 08′	73° 40′	1609	NW

Results and Discussion

Location of sampling sites are shown in Fig. 1 while detail of each site i.e. main location, site name, geographical coordinates, elevation and aspect are presented in. Phytosociological attributes and absolute values are depicted in Table 2.

Cluster analysis: Six groups of trees were recognized by Ward's cluster analysis (Fig. 2). Each group is dominated by different conifer tree species.

Group-I *Pinus wallichiana*: Group-I, the largest among all other groups, consists of seven stands this species appeared as a pure stand in five location. Out of three species present in this group, *Pinus wallichiana* is the first dominant tree species (average importance value was 76) followed by *Cedrus deodara* and *Picea smithiana* with average importance values of 15 and 13 respectively. This group is similar to Bokhari *et al.* (2013) community analysis based on floristic composition of this area. Pure stands of *Pinus wallichiana* were also reported from various workers in Pakistan i.e. Ahmed *et al.* (2006); Siddiqui *et al.* (2013); Khan (2011); Wahab (2011) & Hussain (2013) that showed its wide ecological amplitude, growing at timber line area too.

Group-II *Pinus roxburghii*: Group-II has three stands in which *Pinus roxburghii* emerged as dominant species (average importance value = 80). However in one location it was present as a pure stand. *Pinus*

wallichiana and *Morus alba* were also found as second dominant species with the importance value of 16 and 5 respectively. Ahmed *et al.* (2006), Champion *et al.* (1965) and Siddiqui *et al.* (2009) recorded this species in some of the sub tropical area of Pakistan. At moist temperate areas of Murree and Azad Kashmir it form lower belt of pine forest associated with broad leaf trees as a sub tropical pine and on slightly high elevation with *Pinus wallichiana.* In Azad Kashmir area it form pure forest (stand 21) at lower elevation (799m) it gradually mix with *Pinus wallichiana* on higher elevation and then replaced completely with *Pinus wallichiana* species. It was highly disturbed species, most of the local people continuously cutting its lower branches and they left umbrella shape tall tree.

Group-III *Cedrus deodara* and *Pinus wallichiana*: This group consists of six stands with *Cedrus deodara* as first and *Pinus wallichiana* as second dominating species. *Cedrus deodara* occurred as prominent species with highest average importance value of 60 and that of *Pinus wallichiana*, the second dominant species with the average importance value of 40. In two stand *Pinus wallichiana* is leading dominant species *Cedrus deodara* as a second dominant species. *Cedrus deodara* considered as a dry temperate species (Champion *et al.,* 1965) but according to Ahmed *et al.* (2006) it has wide ecology amplitude, distributing dry, moist and timber line areas. Due to economics value and cutting it may be numerically less in two stands therefore Bokhari *et al.* (2013) also consider it same community as present in Group III.

Group-IV *Abies pindrow*: Group-IV comprising of five stands, is characterized by the presence of four species, out of which three were from gymnosperms and one from angiosperms. *Abies pindrow* was found as first dominant species with 64 to 91 importance value associate with *Aesculus indica* (importance value 11 to 30), *Picea smithiana* (importance value = 10) and *Pinus wallichiana* (average importance value = 9). *Abies pindrow* located at higher elevation (2740m) in three locations in this group. This species also occur in dry, moist and timber line areas of northern area of Pakistan and reported by many workers i.e., Ahmed *et al.* (2006) and Siddiqui *et al.* (2013).

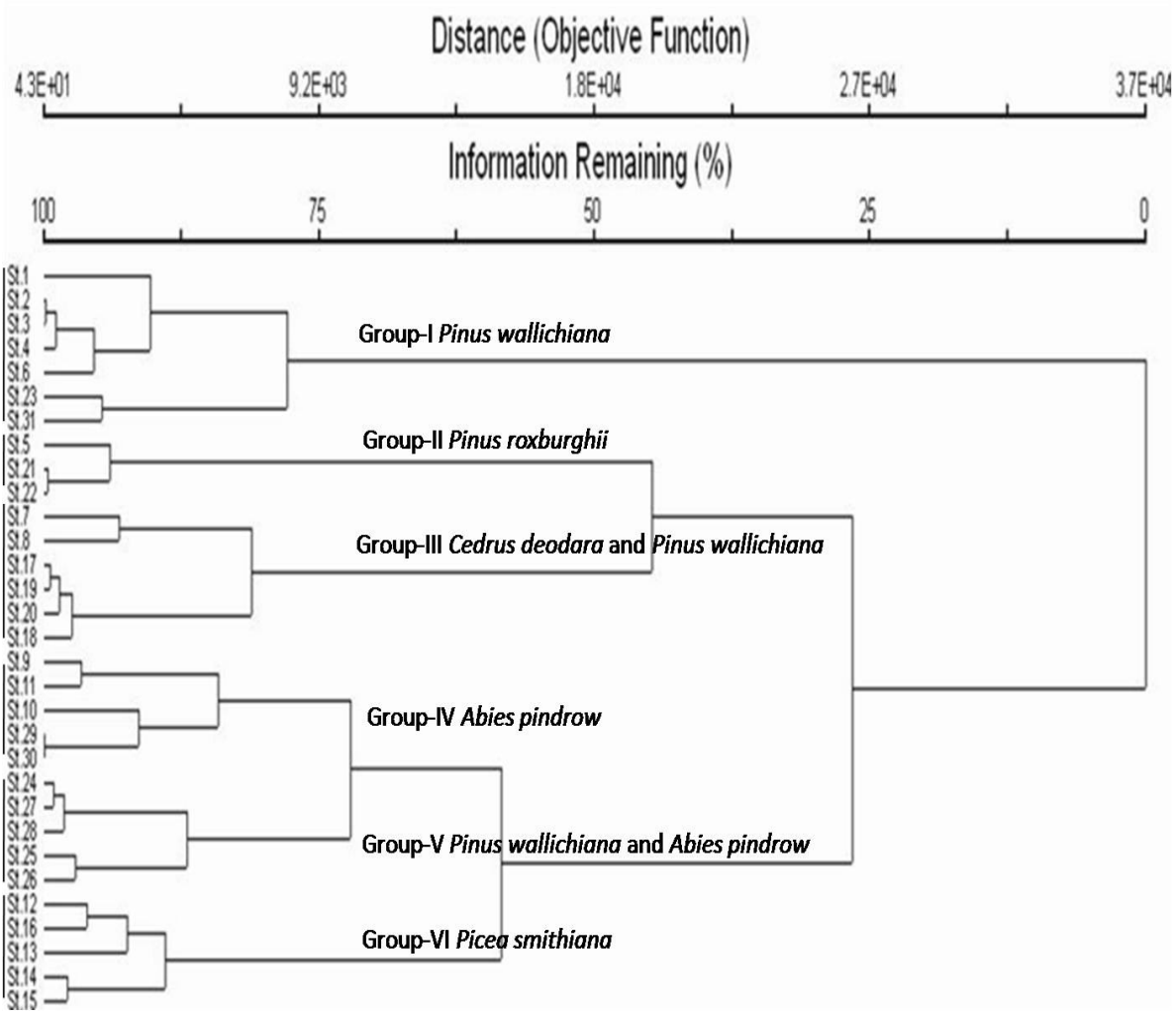

Fig. 2. Dendrogram obtained by Ward's cluster analysis showing VI groups of tree vegetation (data of 31 stands) from various coniferous forests of Azad Jammu and Kashmir.

Table 2. Phytosociological attributes and absolute values of each tree species in thirty one forests of Azad Jammu and Kashmir.

Sr. No.	Sites	Species	IVI	Density ha^{-1}	BA m^2ha^{-1}
1.	Mora Sadiq	*Pinus wallichiana*	100	183	85
2.	Mora Sadiq	*Pinus wallichiana*	100	151	71
3.	Mora Sadiq	*Pinus wallichiana*	100	130	51
4.	Mora Sadiq	*Pinus wallichiana*	100	150	62
5.	Chakothi	*Pinus roxburghii*	84	113	48
		Pinus wallichiana	16	30	2.45
6.	Keran	*Pinus wallichiana*	85	135	57
		Cedrus deodara	15	28	9
7.	Keran	*Pinus wallichiana*	56	89	30.2
		Cedrus deodara	44	65	21.8
8.	Keran	*Pinus wallichiana*	69	112	40
		Cedrus deodara	31	41	20.3
9.	Arrung Kail	*Abies pindrow*	64	86	30
		Aesculus indica	30	58	3.7
		Picea smithiana	6	12	1
10.	Arrung Kail	*Abies pindrow*	74	122	30
		Picea smithiana	15	28	6.4
		Aesculus indica	11	16	1.26
11.	Arrung Kail	*Abies pindrow*	73	101	48
		Aesculus indica	27	47	3
12.	Kail	*Picea smithiana*	53	70	55.2
		Abies pindrow	28	52	14
		Aesculus indica	19	45	2.3
13.	Kail	*Picea smithiana*	67	105	51.4
		Aesculus indica	19	38	13.2
		Abies pindrow	14	18	3.39
14.	Kail	*Picea smithiana*	79	115	50
		Taxus fuana	20	46	4.17
		Betula utilis	1	2	0.02
15.	Kail	*Picea smithiana*	80	128	78
		Abies pindrow	20	21	3
16.	Kail	*Picea smithiana*	60	89	45
		Abies pindrow	40	74	19
17.	Sharda	*Cedrus deodara*	68	104	29
		Pinus wallichiana	32	39	14
18.	Sharda	*Cedrus deodara*	67	107	35
		Pinus wallichiana	23	38	6
19.	Sharda	*Cedrus deodara*	78	94	27
		Pinus wallichiana	22	32	4
20.	Sharda	*Cedrus deodara*	89	132	48
		Pinus wallichiana	11	18	4
21.	Muzaffarabad	*Pinus roxburghii*	100	164	16
22.	Muzaffarabad	*Pinus roxburghii*	97	130	7
		Morus alba	3	5	1
23.	Pir Chinasi	*Pinus wallichiana*	87	166	25
		Picea smithiana	13	15	6
24.	Sudhan Gali	*Abies pindrow*	60	100	57
		Pinus wallichiana	40	83	32
25.	Sudhan Gali	*Pinus wallichiana*	76	158	31
		Abies pindrow	24	47	16
26.	Sudhan Gali	*Pinus wallichiana*	65	134	42
		Abies pindrow	35	54	25
27.	Sudhan Gali	*Abies pindrow*	64	91	21
		Pinus wallichiana	36	89	3
28.	Sudhan Gali	*Abies pindrow*	73	127	41.7
		Pinus wallichiana	27	53	7.3
29.	Sudhan Gali	*Abies pindrow*	89	165	55
		Pinus wallichiana	11	19	4
30.	Sudhan Gali	*Abies pindrow*	92	156	47.63
		Pinus wallichiana	8	20	0.37
31.	Chikar	*Pinus wallichiana*	100	168	31

Key to abbreviations: IVI= Importance Value Index; BA= Basal Area

Group-V *Pinus wallichiana* and *Abies pindrow*: This group, just like Group-IV consists of five stands. *Pinus wallichiana* was the first dominating species in this group (average importance value = 55) followed by *Abies pindrow* (average importance value = 45). In three stand *Abies pindrow* is dominating as a first leading species with 60 and 70 importance values. This species was growing at lower elevation (2400m to 2500m) than pervious group. It is associated with *Pinus wallichiana* or it from small patches, the group was named *P. wallichiana* and *Abies* community.

Group-VI *Picea smithiana*: Group-VI includes 5 stands and has five species, three species from gymnosperms and two from angiosperms. *Picea smithiana* was found as first dominating species (with 53 to 80 importance value) while the second dominant species was *Abies pindrow* having (4 to 20 importance values). *Taxus fuana* and *Aesculus indica* were also present with average importance values of 19 and 20 respectively. *Betula utilis* of this group had lowest average importance value which was 1. The elevations range of this group 2445m to 2663m. According to Ahmed *et al.* (2006) *Picea smithiana* prefer to grow at moist sites of dry temperate area and found in scattered form in moist temperate sites. Near timber line it is associated with *Betula utilis* which replaced it towards the timber line. The largest pure forest of *Picea smithiana* was located at Nalter of Gilgit/ Baltistan area of Pakistan.

Stand Ordination of tree data: Two dimensional non-metric multidimensional scaling (NMS) ordination was applied on vegetation data (Fig. 3a-3c). It showed that a continuous pattern existed between axes 1 and 3, axes 2 and 3. Six groups separated out by Ward's cluster analysis were superimposed on the ordination plane. In both of these axes, the distribution of stands is more or less similar but pattern is slightly different in Fig. 3a and 3b. In both of axes 1 and 3 and 2 and 3, five groups (1, 3, 4, 5 and 6) are placed on the upper position of the diagram while the only group-II is placed in lower middle of the diagram.

Group II belongs to lowest elevation (799m to 1111m) had lowest density (147 / ha^{-1}) and lowest basal area (24.6 m^2 ha^{-1}) while group V occupied highest (186 ha^{-1}) density hence distributed two extreme sides of both figures. Ordination diagrams also clearly separated sub tropical stands on lower most position while moist temperate stands or groups on upper most position except group 6 which is also dry temperate group due to presence of *Picea smithiana* as a dominant species. In Fig. 3a the position of stands and species are on extreme upper and right side of the ordination space. In both ordination diagrams group 1 and 3 located on the left side of the group 5 while group 4 and 6 are on the right side. Some stand gathered on classification groups are out in ordination groups it may be due to the disturbed nature of the vegetation but most of them fall in similar groups.

In general the six associations produced by cluster analysis were plotted on a scattered diagram. The groups were well classified and well separated out in ordination. According to Kent & Coker, 1992 and Song *et al.,* 2009, Importance value index (IVI) of trees explains abundance and dominance of a species in a community of specific area. Following the same approach i.e. using IVI of trees, cluster analysis was done in the present study. Six communities of plants were recognized, in which *Pinus wallichiana* was the dominant species in most of the communities followed by *Abies pindrow* and *Picea smithiana*. The results indicated by Wazir *et al.* (2008) showed that topography and geo-morphological parameters play an important role in defining vegetation of an area. Siddiqui *et al.* (2010) describe the vegetation from different moist temperate areas of Pakistan and Azad Kashmir, they observed the clusters of species are preferred to grow in specific ecological condition, they recorded all associations except the group of *Pinus roxburghii*, it could be due to altitudinal gradient.

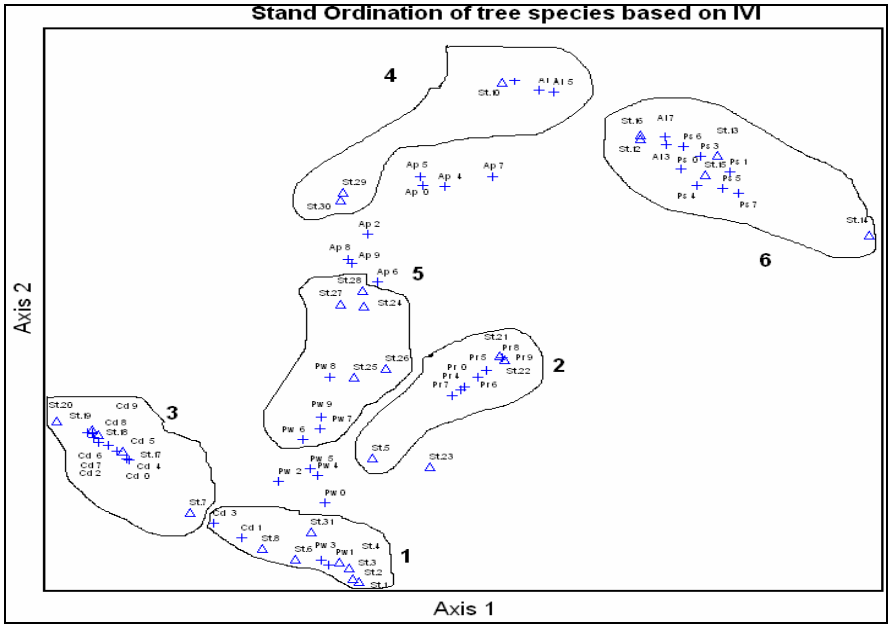

Fig. 3a. Showing NMS stand ordination between axis 1 and 2 of trees species based on IVI.
Note: Δ Sign showing stand number + Sign showing species number.

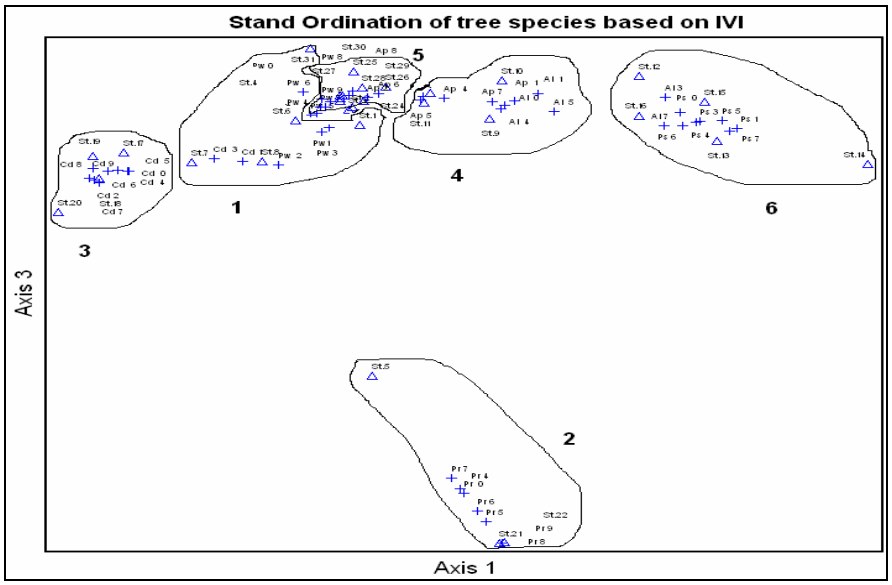

Fig. 3b. Showing NMS stand ordination between axis 1 and 3 of trees species based on IVI.
Note: Δ Sign showing stand number +Sign showing species number

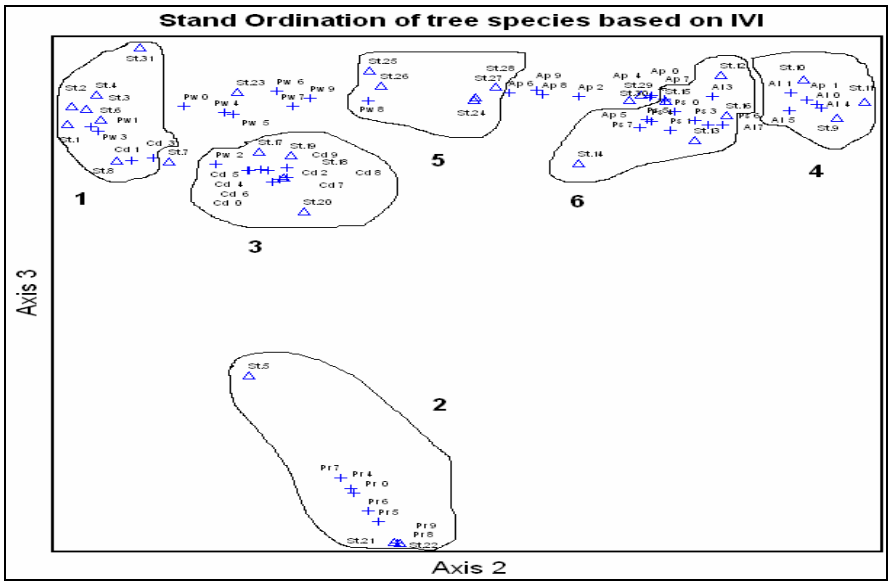

Fig. 3c. Showing NMS stand ordination between axis 2 and 3 of trees species based on IVI.
Note: Δ Sign showing stand number + Sign showing species number

Due to various natural disturbances (like earthquakes and landslides) and anthropogenic interferences (like cutting, lumbering, fueling purpose, furniture & fixtures and thatching), these forests are disappearing gradually and this rate is enhanced since last two to three decades. It is anticipated that these rich forests will be diminishing in near future if these destructive practices are going on in the same manner. The government and various other non-government organizations need to give more emphasis on the conservation and maintenance of these disturbed forests. It is hoped that these studies will be useful for additional research of these disturbed conifer forests of Azad Kashmir.

As a result of Ward's cluster analysis and ordination by NMS, six groups of tree vegetation were classified. Group-I is the largest group composed of seven stands which consists of three species. *Pinus wallichiana* emerged as dominant species in this group. Group-II consists of three stands, composed of three species dominated by *Pinus roxburghii*. Group-III is composed of six stands dominated by *Cedrus deodara*. Group-IV, V and VI are composed of five stands each and dominated by *Abies pindrow*, *Pinus wallichiana* and *Picea smithiana* respectively.

Due to extensive topographic variations in the areas of Azad Kashmir, there exists a diversity of plant species. The diverse flora comprises of bushy vegetation in arid regions while at higher elevations there exist alpine flora.

Common tree species are *Acer oblongum* L., *Androsace umbellata* (Lour.) Merrill, *Cornus macrophylla* Wall., *Diospyros lotus* L., *Rhus succedanea* L., *Taxus fuana* Nan Li & R.R. Mill and *Vibernum cylindricum* Ham. ex D. Don. *Dodonaea viscosa* (L.) Jacq., *Juniperus squamata* Buch.-Ham. ex Lambert, *Lonicera quinquelocular*is Hardw., *Lyonia ovalifolia* (Wall.) Drude, *Sageretia theezans* (L.) Brongn. and *Solanum verbascifolium* L. were commonly occurring shrubs. *Boenninghausenia albiflora* (Hk.) Reichb. ex Heynh., *Geranium nepalense* Sweet and *Oxalis acetosella* L. were among perennial herbs. At higher elevations, there were Barbers (*Berberis lycium* Royle) and Birch (*Betula utilis* D. Don). There were also a great number of herbs. At higher altitudes, the mountainous area was covered with thick Fir (*Abies pindrow* Royle), Deodar (*Cedrus deodara* (Roxb. ex Lamb.) G. Don), Walnut (*Juglans regia* L.), Pine (*Pinus wallichiana* A.B. Jackson). and Willow (*Salix* spp.), which are the part of the rich flora of Neelum Valley (Azad Kashmir) and adjacent northern areas of Pakistan (Prithivi, 1978). Present investigation showed *Pinus roxburghii* on lower elevation and *Picea smithiana*, *Aesculus indica, Taxus fuana, Betula utilis* and *Morus alba* beside pine species mentioned by Prithivi (1978). About 10.6% of the total flora of Pakistan is represented in the area of Sino Japanese region which includes Azad Kashmir also (Ali & Qaiser, 1986).

It is concluded that both cluster analysis and ordination techniques were able to delimit the plant association on the basis of their Importance value index. Similarly these techniques were helpful to classify structure of different vegetation groups and interrelationship among different species of these disturbed forests of Azad Jammu and Kashmir-Pakistan.

This study provides some useful ecological data about different coniferous forests of Azad Jammu & Kashmir-Pakistan, which would be useful for the students, scientists and planners, working directly or indirectly on the issues like climatology, hydrology, geology, forestry, seismology, glaciology, etc. The sampled forests structure showed that some of the sites, due to its topography, were in natural condition/least disturbed due to less human interference and natural disasters like earthquake and resulting landslides. On the other hand, some of the forests, which were present near fault line, were highly disturbed. It was also observed that the local inhabitants usually collect these affected trees for their domestic purposes.

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